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ABSTRACT

Science educators from Bangladesh, China, India, Malaysia, Nepal, Pakistan, Philippines, Korea, and Sri Lanka met to: (1) review current experiences in the preparation of science teachers and teacher educators and their continuing education in the nine countries, as well as to consider major trends, issues, and problems related to the training and retraining of science teachers and teacher educators; (2) define and illustrate the concept of "open competence"; (3) identify the competencies and attitudes needed by science teachers and science teacher educators to cope with changes in science education; (4) suggest strategies for designing and developing science teacher education programs at the pre-service, in-service, and continuing education levels, with focus on developing open competence; and (5) make suggestions for follow-up inter-country cooperative activities and national actions. Each of these areas is addressed in separate chapters of this five-chapter report. A list of participants, resource persons, and observers is included. (JN)

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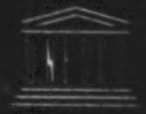

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This is a report of a Technical Working Group which was attended by ten science educators from Bangladesh, China, India, Malaysia, Nepal, Pakistan, Philippines, Republic of Korea and Sri Lanka to review the current experiences on the preparation of science teachers and teacher educators and their continuing education; to define and illustrate the concept of 'open competence'; identify the competences and attitudes needed by science teachers and science teacher educators to cope with the changes in science education; suggest strategies for designing and developing science teacher education programmes at the pre-service, in-service and continuing education levels with focus on developing open competence; and make suggestions for follow-up inter-country cooperative activities and national actions.

The Technical Working Group was convened at the invitation of the Unesco Regional Office for Education in Asia and the Pacific (ROEAP) and was jointly organized by its Asian Centre of Educational Innovation for Development (ACEID) and the Institute for Science and Mathematics Education Development (ISMED), University of the Philippines, and was held at ISMED, Philippines from 17 – 27 July 1984.

The Meeting carried out its deliberations under the chairmanship of Dr. M.A. Rehman (Pakistan) with Dr. Potenciana Cruz (Philippines) assisting as Vice-Chairman and Dr. V. Kesavan (India) and Mr. A.H. Ali (Malaysia) as rapporteurs.

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Chapter One

SUMMARY AND REVIEW OF COUNTRY EXPERIENCES

In this chapter are given, countrywise, the brief summaries of the programmes related to pre-service, in-service and continuing education of science teachers that are being currently followed in the participating countries. This is followed by a synthesis of major trends, issues and problems related to the training and retraining of science teachers and teacher educators.

BANGLADESH

Bangladesh has a 5+ 3+ 2 + 2 system for school education. At the end of 10th grade, a public examination is held and it leads to a Secondary School Certificate (SSC). SSC is followed by a 2 year programme of higher secondary education at the end of which (12th grade) a public examination is conducted and this leads to a Higher Secondary Certificate (HSC). HSC is preparatory for entry into a university which offers a B.Sc. degree (1st degree) at the end of Grade 14, and a Master's degree (M.Sc.) at the end of Grade 16.

For becoming a primary school (grades I-V) teacher, a man must have a HSC and a woman a SSC to be followed by a 1-year programme of professional education and training at the Primary Teacher Training Institute (PTI). The PTI programme leads to a Certificate-in-Education (C-in-Ed).

In order to qualify for teaching science in the junior secondary schools (grades VI-VIII), a teacher must have a HSC in the Science Stream. Teacher training is not a must for such a teacher. However, many will have a B.Sc., and some may have a C-in-Ed.

A secondary school (grades IX-X) science teacher must have a B.Sc. degree. He or she may also have a B.Ed. degree given by a University on the basis of a professional teacher training programme offered by a Teachers' Training College (TTC).

The C-in-Ed. Programme given in the P.T.I. has courses in educational foundation, methodology (pedagogy) and practice teaching. The method courses contain some elements of science content (about 20%) also. The B.Ed. programme run by a TTC has courses relating to educational foundation studies, methods of

teaching and practice teaching. The weightage (for the purposes of examination and certification/diploma) is as follows:

a) C-in-Ed.

Foundation - 20%, Method - 50%, Practice teaching - 20%, and Institute Record - 10%.

b) B.Ed.

Foundation - 50%, Method - 20% and Practice teaching - 30%.

In-service activities

A National Academy for Primary Education (NAPE) has been established (1978) to cater, inter alia, to the needs of updating the teacher educators and others concerned (with primary teacher training) through retraining, reorientation and in-service programmes. Similarly, the National Institute of Educational Administration, Extension and Research (NIEAER) is catering to the needs of updating and retraining of teacher educators (engaged in the training and education of secondary school teachers) through in-service programmes. The NIEAER is also conducting training programmes for the teachers of science and mathematics at the secondary level. The NIEAER also runs in-service training programmes for higher secondary teachers.

At present, there are no programmes relating to the continuing education of science teachers and teacher educators.

PEOPLE'S REPUBLIC OF CHINA

Pre-service training programme

The pre-service preparation of Secondary Science Teachers is the function of institutions of higher teachers' education. The 1982 statistics show that there were 194 such institutions in the country, which were supposed to turn out 320,000 graduates during the period of the sixth five-year plan (1981-1985) and about 500,000 during the period of the seventh five-year plan (1986-1990).

Measures being taken to improve pre-service training

To improve teacher education, the following two measures have been taken into consideration.

1. To give top priority to the development of a number of key normal universities and teachers' colleges, which will serve both as centers of education and centers of scientific research.

2. To remould the curriculum and instructional organization of institutions of higher teachers' education. Efforts are to be made to identify the essential knowledge (key concepts and understandings) and pedagogical aspects (competences, processes and methodologies) for a qualified science teacher, and to create a judicious balance between the training in an academic discipline and training in pedagogy, and between practice teaching and field work.

Future directions

Two different school systems will be established. The key normal universities and teachers colleges will adopt a five year system while other normal universities and teachers colleges will adopt a four year system. Instructional arrangements in the key universities and colleges will be organized in two different ways. One will be to offer pedagogical courses and to conduct field work simultaneously throughout the five years; the other to concentrate on academic discipline instruction in the first four years before going on to pedagogical courses and field work in the last year. The second approach is applicable to students studying at comprehensive universities who plan to enter the teaching profession. In order to differentiate the graduates from five year normal universities and colleges, a double bachelor's degree system is to be set up, namely, graduates from key normal universities and teachers colleges will be awarded both a Bachelor of Arts/Science and a Bachelor of Education degree.

The time alloted for pedagogical courses will be expanded, and attempts will be made to integrate the teacher's instruction with probation, field work, and investigation and study on the part of the students. To mobilize the enthusiasm and creativity of the students, the methods of elicitation and group discussion will be employed in the process of teaching and learning. Indulgence in theory without any relevance to real situations must be done away with.

In-service and continuing education programmes

The Government policy demands that by 1990 all secondary science teachers should come up to the standards of a fully qualified teacher. Consequently, the continuing education of secondary science teachers falls into two categories. One focuses on helping

the unqualified techers to become qualified, the other is for the further improvement of the qualified ones. These two concerns are pursued in the following different ways.

a) Science teachers with teaching problems are helped, above all, to overcome the "textbook barriers" (understanding and clarifying the science concepts and principles included in the textbooks).

Experiences gathered in various parts of the country show that one of the effective ways of helping teachers get over the textbook barriers, is to conduct workshops at the provincial, regional and county levels, where new textbooks are examined and discussed by selected master teachers,who then go back to do systematic explanations and illustration to their fellow teachers concerned in their workplaces. The workshops are organized by sections for instruction and research at the three levels of school education, with the help of the local education institutes and higher educational institutions concerned.

b) Younger teachers who have overcome the textbook barriers are selected on the basis of competition and recommendation, and are provided chances of systematic preservice training (released from their regular work on full pay), if they have a relatively solid professional foundation and show commitment to education, so that they may become fully qualified and eventually come out as mainstay of the teaching force.

c) Education intitutes at the provincial level responsible for trainin upper secondary science teachers and those at the regional level responsible for training lower secondary teachers offer courses on the basis of their own teaching programmes, instead of following the examples of formal teachers colleges, since teachers to be trained are adults and already somewhat experienced in teaching.

d) The number of teachers who have the chance to get training at education institutes is limited. To most of the teachers who have overcome or are struggling at the 'textbook barriers', the main way to improve themselves is through spare time education - "learning while teaching". Various types of programmes are available for this purpose, e.g. attendance at correspondence schools or TV universities; participation in activities carried out by instruction and research sections of the local science centres; self-study.

Spare time education is a big concern of education departments at all levels - provincial, regional and county. They frequently try to get academic bodies concerned to give advice and help to science teachers in a variety of ways. In some places, teams composed of science specialists, scholars and experienced teachers make, from time to time, a circuit of their areas and give lectures on various topics which are of interest to these science teachers.

To keep up with the rapid development of science and technology, the qualified science teachers are also urged and helped to improve themselves, to renew their knowledge and gain access to new theories and new findings in their fields. Among other things, scholars and university people concerned are invited to give lectures or run short-term courses which focus on the development and application of modern science and technology, such as laser technology in physics, theory of structure in chemistry, genetic engineering in biology. These activities have proved helpful in broadening the teachers' horizon of scientific culture, and in promoting their competence to understand and employ newly developed knowledge. Science teachers have also benefited from modern perspectives of education and pedagogy, modern instructional materials and their application. To develop the experimental skills of science teachers, lectures and training classes on relevant topics are a common practice in some provinces and municipalities.

Another attempt being made for continuing education of science teachers is through recommending and providing access to publications on science education, both domestic and foreign. Publications such as Biology Bulletin, Chemistry Bulletin, Physics Bulletin and some others, with their rich contents, are of great value to the teachers who are attempting to seek the right direction for science education reform or searching for new instructional strategies and methodologies.

INDIA

Education in India is primarily a state responsibility and each state has autonomy in organizing programmes of education. The broad pattern of school education is of 12 years duration and is in three levels: (i) primary (classes 1 to 5), (ii) secondary (classes 6 to 10) and (iii) higher secondary (classes 11 and 12). Science is an integral part of general education up to class 10.

Training of science teachers and teacher educators

Teacher training for primary school techers is offered to candidates who have completed a minimum of 10 years of schooling and is of two years duration, leading to a primary teacher certificate. Training for secondary school science teachers is of one year duration after completion of the first university degree with science subjects. Secondary teacher training is offered in teacher training colleges which are affiliated to universities and leads to a B.Ed. degree. The teacher training mainly emphasizes on pedagogical aspects of teaching and no attempt is made to integrate the content and methodology.

In 1976, the government of India constituted the National Council for Teacher Education (NCTE) to advise the government on matters relating to teacher education. On the basis of the recommendations, the teacher education programme has been completely revamped. The weightage for various areas in the one-year B.Ed. curriculum is now as follows.

a) Pedagogical theory (Teacher and education in the emerging society, Educational Psychology) - 20%.

b) Working with community - 20%.

c) Content-cum-methodology and practice teaching including related practical work - 60%.

One of the first attempts to translate the recommendations of the NCTE into a workable curriculum has been made at the Regional College of Education Mysore. The special feature of the science courses at the one year B.Ed. level is approaching the science content from a broader perspective, so that the pupil-teacher realizes how some of the important ideas in science have evolved and also understands the methods of science employed. The methods of teaching science is implicit in this exercise.

Since the one year teacher training programme was found to be too short a time for inculcating values and skills required for the profession, the National Council of Educational Research and Training (NCERT) is running a four year integrated and inter-disciplinary course (B.Sc.Ed.) in science teacher education as an experiment, at its four Regional Colleges of Education. Another experimental course, the only one of its kind in the country, is the two-year M.Sc.Ed. course to prepare teachers for the higher secondary stage. The courses in Physics, Chemistry and Mathematics education are being run at the Regional College of Education, Mysore, while a course in Life Sciences education is being run at the Regional College of Education, Bhubaneshwar. The M.Sc.Ed. curriculum involves not only the specific science discipline at post-graduate level but also the essential ingredients of pedagogy like philosophy of science, curriculum planning, science education,

and test measurements.

The status of in-service education

The NCERT and various state agencies such as State Institutes of Education (SIEs), State Institutes of Science Education (SISEs), State Councils of Educational Research and Training (SCERTs) and Centres of Continuing Eduction (CCEs) have been for years, organizing a variety of programmes for in-service and continuing education of teachers and teacher educators. The different types of programmes, their duration and their expected outcomes are given on page 8.

MALAYSIA

In Malaysia, pre-service teacher education takes place at two levels, namely, (a) for upper secondary and (b) for lower secondary and primary levels.

Upper secondary science (for grades 10, 11, 12) teachers are trained at the five local universities as well as at selected accredited universities abroad, particularly in England, United States of America, Australia and New Zealand. The programmes are either the consecutive post-graduate teaching diploma that follows the four-year bachelor's degree in a chosen science discipline followed by a one-year Diploma or Certificate in Education at a university or a teacher's college or the concurrent four-year academic bachelor's degree with integrated teacher education components.

Lower secondary science teachers (for grades 7-9 levels) are trained at a number of teachers' colleges under the central management of the Ministry of Education. The students, usually with the minimum of good credits in the sciences at the equivalent of grade 11 or higher,are offered double-major courses in Science and Mathematics or other combinations for a period of three years.

All primary school techers (standards 1-6) are termed "general purpose," except for English, Music and Religion. However about 7.5% of the curriculum comprises science education to enable the potential teachers to handle the new subject of "Man and the Environment" in which specified concepts and skills of science form an integral part.

In-service and continuing education programmes for science teachers, particularly for secondary schools are currently not receiving much attention in Malaysia for two main reasons:

Scope and Pattern of In-service Teacher Education (India)

	Course	Duration	Agency	Outcomes
1.	B.Ed. Correspondence	14 months correspondence and 4 months (2 summers) contact	Universities and Regional Colleges of Education	Acquiring the needed qualification to teach in the secondary schools
2.	M.Ed. Correspondence	10 months correspondence and 1 month contact	Universities	Professional advancement
3.	Seminar and Symposia	1 week	NCERT, SCERT, and SIE	Sharing experiences on various aspects of school education
4.	Orientation courses	1 to 2 weeks	NCERT, RCEs, Field Offices, SCERT and SIE	Acquainting the teacher with latest developments in content, methodology and innovative practices
5.	Training programmes	2 to 3 weeks	as in 4 above	Developing competences to become effective teachers
6.	Workshops	2 to 3 weeks	as in 4 above	Development of various kinds of instructional materials
7.	Summer Institutes	3 to 5 weeks	as in 4 above and also KVS*	Development of instructional materials and content enrichment
8.	Centres of Continuing Education (CCE)	Weekends	NCERT and State Education agencies	Content enrichment and development of competencies related to teaching.

* KVS (Kendriya Vidyalaya Sangathan or Central Schools Organization)

a) priority is being given to the in-service training of specific groups of primary school teachers to enable them to cope with the strategies of the new primary school curriculum.

b) the whole concept of 'General Education for All', including the 'Science for All' sub-concept, throughout the entire eleven-year school system is being examined, clarified and re-structured from Grade one to Grade eleven.

However, under normal circumstances in-service training programmes can range in duration from one week to four weeks, six months or, at a more structured and certificated level, for a whole year at selected teachers' colleges.

Currently, Science for All, is taught at the level of grade seven, eight and nine in the form of Integrated Science in which the various concepts and skills of physics, chemistry and biology are integrated into thematic units. But specific social problems and issues are not an integral part of the curriculum. In the new structure and concept of general education, perhaps a more social and personal approach would be introduced.

Beginning from grade ten onwards students are streamed into three main groups.

a) The "Pure Science" group of Physics, Chemistry and Biology geared for higher studies in science;

b) The "Arts" group being exposed only to General Science or Human and Social Biology;

c) The "Technical and Vocational" group.

NEPAL

Pre-service training programme

The pre-service training programme is mainly conducted by the Institute of Education (IOE) of the Tribhuvan University. The requirement for the lower secondary teacher training programme (Proficiency Cetificate in Education) is SLC (10th grade graduation) and the duration of training programme is 2 years. The training of secondary school teacher (B.Ed.) is available through two models. The one requires 2 years professional training after proficiency certificate and the other is a one year programme after a Bachelor degree in science. The weightage to different components in these three programmes in terms of percentages of distribution of marks is as follows:

Training of science teachers and teacher educators

	Proficiency Certificate in Education	Two-years Bachelor Degree in Education	One-year Bachelor Degree in Education
1. General Education	18.20	-	-
2. Professional Education	18.20	27.28	60.00
3. Specialization I	31.80	36.36	20.00
4. Specialization II	31.80	36.36	20.00

Of the 31.8% of the marks allotted to science specialization in proficiency certificate, 9.1% is allotted to physics, chemistry, and biology each, and the remaining 4.5% is allotted to science methodology.

The 36.36% of the total marks allotted to science specialization in two-year B.Ed. course are divided equally among physics, chemistry, biology and methodology.

In-service training programme

The IOE conducts in-service training for untrained primary teachers working in different parts of the country. The programme, in general, contains a package of subjects in primary school curriculum. The duration of the programme is 5 months and at the end of the programme the teacher is awarded a certificate of training. Science is one of the subjects in the primary training course and accounts for 16.66% of the time of the training period. The content of each unit is translated in terms of competences together with the teaching strategies needed to teach various content units.

The IOE has recently developed a five-month package programme for lower secondary science teachers which is to be implemented very soon. The contents of the science education courses of the package are purely on structured activities to be carried out by the teachers and are associated with competences.

Science Education Development Centre (SEDC)

Recently a Science Education Development Centre has been established. In the near future, the Centre plans to organize and conduct science teacher educator training programmes. The teacher educators, on completion of the training, will be assigned to Science Education Development Units (SEDUs) to be established in 25 selected secondary schools throughout the nation. They will organize, conduct, supervise and evaluate lower secondary and

secondary in-service science teacher training programmes of short duration.

Programme for Continuing Education

There is no specific regular programme in continuing education, except through academic upgrading programme to earn higher degrees. However, the IOE conducts periodically workshops and seminars to exchange experiences.

PAKISTAN

Pre-service training

Primary school teachers undergo a one year training programme after 10-years of schooling, whereas this intake for one year teacher training programme for middle school (classes VI-VIII) teachers takes place after 12-years of schooling. The training of a secondary school science teacher is available through two models. The one requires a one year training after earning a B.Sc. degree, (14 years of education) and the other involves a three year integrated programme after 12 years of schooling.

In-service training

Science teachers at all levels are expected to undergo an intensive in-service training programme at least once in five years. Such programmes are held during summer vacations. Travel, residence and maintenance are provided. The training is conducted at Education Extension Centres.

An 'Institute for Promotion of Science Education' is being established to act, among other things, as a nerve centre for the promotion of research-based activities in science education; as a clearing house to encourage, stimulate and popularize science education and to prepare competent, committed and dedicated teams of science educators through built in staff development programmes.

Mobile training squads are being organized to visit schools for providing on-the-spot training and assistance to working science teachers.

Continuing Education

Linkages are being established between various tiers of education to allow mutual sharing of experiences, problems and issues. It should thus be possible to provide, on a regular and continuous basis, flow of information and expertise from one to the other level of institution.

Training of science teachers and teacher educators

Distance education techniques are being used, through Allama Iqbal Open University, to provide teacher training programmes in content and methodology on a continuous basis.

Concept of cluster schools is being developed at various levels, to allow participating school teachers benefit from the expertise and facilities available at the Resource School of the cluster.

Provision of study leave on full pay is being made available to enable working teachers improve their qualifications.

Audio- and video-cassettes are being developed to up-date science teachers both in content and methodology.

A magazine is being planned to disseminate current and new information about processes and techniques in the area of science and technology education.

PHILIPPINES

Pre-service education

The pre-service programme is undertaken by teacher-training colleges and universities, either seprately or in consortium. The degrees offered lead to a Bachelor of Science in Elementary Education (BSEE) or Bachelor of Education (BSE), major in one of the sciences. To qualify for college work, a high school student must pass the National College Entrance Examination (NCEE) given by the Ministry of Education, Culture and Sports (MECS).

For the BSEE degree, the courses are in Eduction, Communication Arts,General Psychology, Performing Arts, Social Science, and Sciences. For the practicum, student teaching is done for 10 weeks in campus and another 10 weeks in off-campus co-operating schools. The BSEE degree requires 144 units. The programme is of four year duration.

For the BSE degree (major in the sciences), courses taken are in Communication Arts, General Psychology, Performing Arts, Social Sciences, Education, and Sciences. Practicum is done during the fourth year with 10 weeks in campus and another 10 weeks in off-campus co-operating schools. Of the 156 units required, 30 are for the major subject. The programme is of four year duration.

The National Science Technology Authority (NSTA) since 1974 to the present (1984) has a funded project for the Bachelor of Science in Physics for Teachers (BSPT) which aims to produce highly qualified and trained physics teachers. The project is implemented

by the Philippine Normal College.

Current science teacher in-service training programmes

The in-service training programmes are undertaken by the Ministry of Education, Culture, and Sports (MECS) Staff Development Division, by the Institute for Science and Mathematics Education Development (ISMED) in co-operation with government agencies like the Science Promotion Institute (SPI) and National Science and Technology Authority (NSTA), by colleges or universities designated as Regional Science Teaching Centres (RSTCs) or Regional Staff Development Centers (RSDCs), by national science teacher's organizations, and by the supervisors of science in the regional, division, district or school levels.

These programmes take the form of seminars, workshops, short-term courses and demonstration teaching in the different levels. The topics dealt with are on such areas as: (i) assessed needs of classroom teachers, administrators or supervisors; (ii) innovations in teaching-learning process; (iii) newly-developed curriculum materials for national, regional, or division-level projects.

Among the assessed needs of in-service teachers are on methods of teaching science; test construction and their interpretation; and science equipment improvisation. Innovations in the teaching-learning processes centre on the production and use of multi-media approaches as video-tape recording, recent concerns and development in biology, physics, and chemistry education. On the newly developed curriculum materials, the in-service programmes focus on the use and evaluation of such materials by classroom teachers. Supervisors and administrators also undergo in-service programmes for the development, mass production, and dissemination of such materials.

Visits to classrooms are also made by the principals or science supervisors to assist teachers in carrying out the teaching-learning process. Master teachers give demonstration lessons on areas such as innovative approaches to science teaching; use of newly developed instructional materials or improvised science equipment. Echo seminars are conducted by teachers or supervisors who have attended short-term courses or training either in the country or abroad to share their newly acquired knowledge or experiences.

Seminar-workshops for science club advisers are undertaken regularly to further develop teacher competences. These activities prepare the teachers to participate actively as advisers of students and pupils in pursuing investigatory science projects

which are later presented in the annual district, division, regional and national level Science Fairs. The Science Promotion Institute (SPI) of the National Science and Technology Authority (NSTA) co-sponsor with the MECS the holding of these multi-level Science Fairs and quizzes which culminate in the selection of the Ten Outstanding Young Scientists (TOYS). Presidential trophies, plaques of recognition and substantial cash and other awards await the top students and adviser winners.

Under the MECS Integrated Scholarship Programme, both the Bureaus of Elementary Education and Secondary Education are having their teachers and school administrators competences upgraded by attending intensive one month retraining programmes in selected universities/teacher training institutions or at the Institute for Science and Mathematics Education Development at the University of the Philippines.

The duration of the in-service programmes vary as these depend on the degree of need of the teachers on the identified topics; on the availability of facilitators, teachers, resources, and time.

Certificates are awarded to participants as incentives to more active participation in such professional activities.

REPUBLIC OF KOREA

Preparation of science teachers and teacher educators

Primary school teachers

There are 11 national primary teacher colleges (PTC), whose academic programme of two years after the 12th grade, has been extended to four years since 1981.

There is a common curriculum for all PTC. The total required number of credits for graduation is 140: among them 5 credits are for science and 4 for science education, 24 for general pedagogical theories and 4 for practical teaching for all students. In addition to these courses, those who are interested in science and may teach science in the upper grades in primary school, take 21 more credits of science courses.

Secondary school science teachers

There are 21 colleges of education (COE) which offer one or more science education majors among physics, chemistry, biology and earth science education, starting after the 12th grade.

Even though COEs do not have a common curriculum, there are many similarities in the offered courses and required credits. The average numbers are: the total required credits for graduation is 140; 57 credits are for sciences, 5 for science education; 14 for general pedagogical theories; and 2 for practical teaching. The COE graduates are certified to teach general science in junior high school and the major course in senior high school.

There are also many colleges of natural science which provide special pedagogy courses for a second level teacher certification for secondary school science teachers, but the government policy is to taper off this programme.

Science teacher educators

The faculty members of departments related to science education in the PTC and COE can be divided conceptually into science and science education lecturers.

At present, the science lecturers are mainly M.S. or Ph.D. degree holders in a science field. Young scientists who have studied abroad have been recruited and their number is expected to increase for a while, but ultimately the science field Ph.Ds from universities in Korea will be able to meet the demand for such lecturers.

Generally, science education lecturers so far have been senior members of the department whose background was mainly science oriented but often with experience in teaching science at secondary schools and/or experience in science education development activities. However, recently the faculty is having young members who have graduated from COE. There are few lecturers with doctoral degree in science education at the moment, but since 1978 the Ministry of Education (MOE) has offered some scholarships each year by competitive examination for study of science education in foreign countries. The MOE also decided to train higher and special science education manpower. As a result, the Seoul National University (SNU) started a doctoral programme in science education in 1984.

During the minimum of 3 years, the students of doctoral course in science education at SNU will take credits in graduate courses (including courses taken during their master degree work). These courses require a minimum of 50% of science and 30% of science education courses. The candidate must also submit two papers: one in science and the other in the science education field.

Training of science teachers and teacher educators

The government has decided to establish a Korean National University of Teacher Education (KNUTE), which is a specially designed and integrated organization for teacher education and in-service training as well as educational research in subjects directly connected to school teaching activities and will start in 1985. It will produce all levels of teachers by different organizational patterns such as separated grouping of faculty members, subject teaching emphasis research institute, attached laboratory schools, continuing in-service education, etc.

Continuing education for science teachers

Regular 240 hour in-service education for status promotion

There is a formal 240 hour in-service course for both the primary and secondary school teachers who have at least three years teaching experience. On completion of the in-service course they are promoted to a higher grade.

In the above programme for primary teachers, the training for science teaching is allocated less than 10% of the total time and is conducted by the science education faculty members of PTCs.

For secondary school teachers, the in-service programme is organized by subject areas which results in a major-licensed area. The training is organized at selected national COEs by the faculty members of the physics, chemistry, biology or earth science education department.

Special 60 hour in-service training for science teachers

In addition to the regular in-service education, the government has provided since 1983, a special science in-service training of 60 hours. This is a requirement for all primary and secondary school science teachers once in every 5 years.

Primary school teachers retraining is carried on at 166 'County Science Materials Room' by selected head science teachers of the county schools, who had been trained at PTC and/or a regional science centre. The secondary science teacher training is carried on by 13 city and provincial Boards of Education (BOE) at their attached regional science centres.

All expenses related to the above in-service training programmes are provided by the government.

Professional activities and assisting media

With the direct and indirect support of the science supervisory section and regional science centres at each BOE, the head science teachers of the primary schools and science teachers of the secondary schools have been carrying on various professional activities: participation in science education research competition; science fair and science teaching materials development competition, where a prize carries weight for promotion and results in professional growth.

Regional and national science teachers associations have been established and activated to hold seminars, workshops, field trips, invite special lecturers, etc.

There are a few magazines which help science teachers, and a small number of TV programmes have been produced for science teachers by the Korean Educational Development Institute (KEDI).

SRI LANKA

Pre-service education

Teacher education in the island is the responsibility of the Government. The training of science teachers is at three different levels - primary, secondary and higher secondary.

At the primary level (grades 0-5), science is integrated with the other areas of study. Usually one teacher handles all the areas of study. Hence, in the teacher education for primary level, science is only one of the many areas of study.

For training to teach science at the secondary level (grades 6 to 10), the minimum entry requirement is the General Certificate of Education (Ordinary) (GCEO) with a good pass in science. In the training course, in addition to pedagogical subjects the trainees study physics, chemistry and biology.

The period of study for the above two categories of teacher-trainees is two years at teacher-colleges and one year in the field.

The science teachers who handle grades 11 and 12 are university graduates in science subjects. They may get the opportunity of being trained at the university after a minimum period of 5 years of teaching.

Training of science teachers and teacher educators

Much could be achieved by the proper designing of pre-service courses. As at present, pre-service courses consist mainly of lectures in all subjects. Laboratory experiences are limited to science subjects. The teaching practice gives only limited experiences in classroom teaching. Various stages of curriculum development need to become part of their experiences.

In addition to the above, a distance education programme has now been initiated.

In-service education of teachers

A systematic and regular in-service teacher education programme has been put into operation by the Curriculum Development Centre (CDC). The basic planning for the in-service is done at the CDC. Seminars are held in all districts of the country with the help of the regional in-service advisers, at the primary and secondary levels.

For science teachers of grades 11-12 level, the in-service is carried out by the CDC staff. The in-service is implemented with the help of staff from teacher's colleges, universities and circuit education officers.

The in-service education programme has now established itself as a quality improvement programme of vital importance which could be further enriched by utilizing the annual national level examinations for the in-service training of science teachers. The various stages in the marking of answer scripts could be profitably utilized for the quality improvement of teachers. These will eventually lead to the improvement of evaluation practices.

REVIEW OF EXPERIENCES

Trends, problems and issues

Science in one form or the other is an integral part of school curriculum at the primary, middle (junior high) and secondary stages of education. However, the starting point where formal science experiences are introduced differ as also the duration for which all pupils are provided such experiences. For example, China, Malaysia, Nepal and Sri Lanka do not have formal science as a subject during the first three years of primary schooling whereas in the Philippines it starts from grade 3.

At the primary stage, science is either taught as environmental studies, general science, nature study or integrated science, drawing the content from three main clusters of living things, matter and energy, and earth and universe.

All the participating countries provide a course of science for all its students at the middle or junior high school stage and here again it is organized either as general, integrated or combined science or as separate disciplines of physics, chemistry, biology and earth science. Excepting Bangladesh and Nepal all the other countries teach science to all the students up to class 10 or even up to class 11/12 as in the case of China, Malaysia and Republic of Korea.

The problems and issues in regard to the above relate mainly to curriculum concerns such as how much weightage to science experiences; emphasis on 'learning by doing'; relevance of science content to real-life situations; the development of curiosity and an inquiring mind; the acquisition of process skills and the formulation of a more detailed set of objectives for science teaching. Another important problem is how to change the traditional orientation of the secondary stage science curriculum, which at present is more geared to preparing for universities and other forms of higher education, relevant to the needs of the majority of the students at this stage to prepare them for the world of work and cope with problems of a fast changing society.

These varying patterns of science education and the issues and problems involved are determining the nature and the scope of the science teacher training programmes.

Pre-service education

Experience of the last two decades shows that inspite of a full recognition that the science teacher has a pivotal role in improving science education, the teacher education programmes have remained much behind the curriculum development efforts, with the result that the objectives of these programmes could not be achieved during their implementation.

The qualifications of teachers handling the subject of science vary considerably in the participating countries. China, Nepal and Sri Lanka do not require any formal training for primary school teachers, who are directly employed after obtaining a High School graduation certificate (10/11 or 12 years of schooling) from a secondary school. Bangladesh and Pakistan require one year of pedagogical training after 10 years of schooling to qualify as a primary school teacher. The other end of the spectrum has countries like Philippines and the Republic of Korea which train their primary school teachers, some of whom could major in elementary science education, through a four year integrated programme of content and methodology. In between are countries like India and Malaysia who prepare the elementary school teachers through a two or three year teacher training programme which includes the elements of both the content of science and pedagogy.

Training of science teachers and teacher educators

It is to be noted that the training programmes are mostly based on the assumption that there is no 'science teacher' per-se for the primary schools. He or she is essentially to handle all the subjects in a grade. However in case of large schools (e.g. Republic of Korea) the provision of a Head Science teacher in a primary school in growing. Similar proposals are under consideration in Pakistan. The Philippines training programmes provide opportunities for trainees to select a major area of specialization as 'elementary science education' so as to provide the leadership role in this regard in large schools.

The major components of these training programmes are: Liberal education, which includes the content of various subjects which find a place in the primary school curriculum such as language(s), mathematics, social studies, science, arts and crafts and physical education; Professional education which mainly includes the principles of education, foundations of education (mainly psychological) and practice teaching. The weightage given to these two major components varies from country to country, but could, on an average, be seen as 40:60. Naturally in the scheme of things, science content and its teaching methods receives very little time for preparing a teacher who could handle the new primary science courses effectively.

Some of the problems and issues being faced with regard to the pre-service education of primary teachers are: low level of communication and computational skills of student teachers; procedures and methods for selecting right type of student teachers; preparation and selection of right type of faculty members with required competences and attitudes; lack of learning materials; linking teaching practice to real classroom situations; attitudes of co-operating teachers; mechanisms for continuing linkages with the student teachers, once they have left the training institution.

For the lower and upper secondary stages of school education, all the countries have separate science teachers who are required to have professional training, excepting in case of Bangladesh and Sri Lanka where professional training is not a requirement for becoming a science teacher. As in the case of primary teacher education, the duration of training varies from one to four years and so does the entry qualifications which ranges from 10 to 12 years schooling with science subjects.

For the training of upper secondary science teachers two main organizational patterns are being followed: the first is where the content of science is learnt in the universities and colleges of natural science at the undergraduate level for a period of 3-4 years leading to a Bachelor of Science degree and then a one year professional training with practice teaching is provided

in a Teacher Training College or University departments of education. This pattern is typical in countries like Bangladesh, India, Malaysia, Nepal and Pakistan. The other pattern is a four year integrated course of science content and pedagogy, including practice teaching, with a smattering of liberal education. This pattern is being followed in China, Philippines and the Republic of Korea on a wide scale and in a few colleges on an experimental scale in India, Malaysia and Pakistan. In some countries like Bangladesh, India and Pakistan no formal training in pedogogy is required for teachers handling classes XI and XII.

The major components of all these training programmes are content (including liberal education), general pedagogical courses such as principles and foundations of education, science education specialization, teaching practice and internship. The weightage given to various components varies from country to country in the pattern being followed. However, in the one year training programme major time is spent on pedagogical subjects and practice teaching, with hardly ten per cent time devoted to content of science, which again is confined to secondary school science content.

Most of the problems and issues referred to under primary teacher education are equally applicable in case of secondary science teacher preparation also. In addition some of the problems and issues being faced and which are unique to the preparation of science teachers are: providing greater depth as well as a broad base of content in all the four major science disciplines, namely, Physics, Chemistry, Biology and Earth Sciences; developing awareness amongst the science student teachers of main social and environmental issues cropping up as a result of applications of science and technology; preparation for moving towards the concept of 'science for all'; catering for the needs of disadvantaged sections of the student population; identifying and nurturing scientific talent; moving from course based to competence based training; developing laboratory skills and techniques; lack of laboratory facilities; preparation of science teacher educators.

In-service and Continuing education

Almost all the countries have been organizing in-service training programmes for its science teachers of elementary and secondary schools. The need for such in-service training had emerged as a result of introducing new science curricula some one to two decades back. The major catalytic and leadership role in providing such in-service training was played by the science curriculum development centres which almost all the countries had established during 1960's and '70s. Different strategies were used such as workshops, seminars, summer schools, master teachers,

orientation course. The duration of these have varied from one to ten weeks depending on the objectives of the training.

There is a growing recognition that curriculum development itself is a continuing process and not a one shot affair, and that scientific knowledge is developing at a very fast pace and explosive application of this knowledge is being made through technology. This is influencing the lives and cultures of the people. In view of this, school science curricula have to be continuously reoriented and improved to prepare future citizens to meet the fast changing situations. The science teacher has therefore also to be continuously upgraded and updated to handle the curricular changes.

In order to help science teachers to develop new competences, attitudes and values, countries have taken many steps to provide in-service training on a continuing basis by developing various infrastructures such as Regional Science Teaching Centres (Philippines), Provincial Science Centres (Republic of Korea), Science Teacher Servicing Centres (Thailand), Continuing Education Centres and State Institutes of Science Education (India), National Institute of Educational Administration, Extension and Research (Bangladesh), Field Science Centres (Sri Lanka), Provincial Extension Centres and Allama Iqbal Open University (Pakistan), Resource Centres (Malaysia).

Some countries have started building networks between the science faculties of the Universities, neighboring Teachers Training Colleges and secondary schools to continuously upgrade the science teacher. A similar attempt is being made by developing 'school clusters' (Sri Lanka, Pakistan, Thailand) with the Central school playing the lead role in improving the quality of science teachers.

In many of the countries the professional organizations of science teachers (including subject wise organizations) are providing opportunities for its members to improve upon their competences and acquire new ones.

Some countries have already made it a requirement for their science teachers to undergo in-service at least once in five years during their service period. Some of these could earn credits towards a higher degree.

It would thus be observed that all the in-service and continuing education programmes are aiming at: (i) helping the existing science teachers to improve their qualifications, both professional and academic, some of them leading to obtaining a higher degree. This provides motivation and chances of vertical mobility to higher grades of pay. Such programmes are mostly

being done through distance education technique (mainly correspondence courses) or through 'sandwich' courses being offered by some universities and colleges, (ii) to help science teachers effectively handle the new science curricula. These have been done mostly through training workshops and seminars conducted by selected centres and training colleges and cover both the content and methodology aspects, and (iii) to provide opportunities for continuous growth. This is being attempted through facilities provided at various types of continuing education centres, professional magazines, lectures by scientists and provision of a variety of instructional materials.

Looking at the vast number of science teachers in the school system of various countries, the facilities for continuing education are still only available for a very limited number of teachers and thus need to be expanded and new innovative programmes to be developed, particularly when countries are moving towards the concept of 'Science for All'.

Table 1. Time Allocation for Compulsory Science Learning
(% of total hours of learning)

Grade Level	BANGLADESH			CHINA			INDIA		
	Age	Course	%	Age	Course	%	Age	Course	%
1	6	Environmental	8.5	6	None	0	6	Environmental	10
2	7	Studies	8.5	7	None	0	7	Studies	10
3	8	General	12.5	8	None	0	8	General	12
4	9	Science	12.5	9		10	9	Science	16
5	10		12.5	10	Nature	10	10		16
6	11	General	15.0	11		10	11	Separate	16
7	12	Science	15.0	12		10	12	Subjects, (Physics,	16
8	13		15.0	13	Math, Physics,	10	13	Chemistry, & Biology)	16
9	14	General Sci	20.0	14	Chem & Bio	40	14		40
10	15	For Science Stream	20.0	15		40	15		40
11	16	Sci Stream w/	60.0	16	Math, Physics	50	16	as elective (Ph, Ch, Bio	60
12	17	Ph,Ch & Math or w/Ph,Ch & Bio	60.0	17	& Chemistry	50	17	Math)	60
13				18	M,Ph,Ch,Bio	60			

Table 1. Time Allocation for Compulsory Science Learning
(% of total hours of learning) .... (Cont'd)

Grade Level	MALAYSIA			NEPAL			PAKISTAN		
	Age	Course	%	Age	Course	%	Age	Course	%
1	6	None	0	6	None	0	6	Living things,	20
2	7	None	0	7	None	0	7	Matter & energy, earth &	20
3	8	None	0	8	None	0	8	universe	17
4	9	Environmental	18	9	Biology	10	9		17
5	10	Science	18	10	Env. Science	10	10		17
6	11		18	11	(Combination	12	11		15
7	12	Integ-	19	12	of the Sciences)	12	12		15
8	13	rated Science	19	13		12	13		15
9	14		19	14	Optional	26	14	Ch, Ph, Bio	40 or 14
10	15	Chem, Bio,	33	15	Science (combination)	26	15	or Gen Sc.	40 or 14
11	16	Physics or Gen Sc.	33				16	Ch, Ph, Bio	60
12	17	Ch, Bio,	75				17	or Ch, Ph, Math	60
13	18	Physics	75						

Table 1. Time Allocation for Compulsory Science Learning (% of total hours of learning) .... (Cont'd)

Grade Level	PHILIPPINES			REP. OF KOREA			SRI LANKA		
	Age	Course	%	Age	Course	%	Age	Course	%
1	7	None	0	6	Integ. Math & Nature	0	6		0
2	8	None	0	7		8	7	None	0
3	9	Integrated	13	8	Nature	9	8		0
4	10	Science	17	9		9	9		0
5	11		11	10		10	10		0
6	12		11	11		10	11	Integ-	10
7	13	Integ.Sc. 1	13	12	Sc. 1	11	12	rated Science	10
8	14	Biology	13	13	Sc. 2	11	13		10
9	15	Chemistry	26	14	Sc. 3	11	14		12.5
10	16	Physics	26	15	Bio 1, Ch. I	12	15		12.5
				16	Ph.I,Ea.Sc. I or Bio I,II; Ch I,	15 or 30	16	Pure & Applied Math, Ph, Ch, Bot,	80.0
				17	II, Ph I, II Ea. Sc. I, II	15 or 30	17	Zoo (any 4)	80.0

Chapter Two

CONCEPT OF "OPEN COMPETENCE"

Background

The Seventh Regional Consultation Meeting on APEID (Bangkok, June 1981), while developing the workplan of APEID for its Third Programming Cycle (1982-1986), established the following 'Development Objectives' for the Programme Area 'Education for Promotion of Scientific and Technological Competence and Creativity':

"The main aim of the programme in this area will be to further strengthen the development of scientific attitudes, understandings and skills among populations both in and out-of-schools, raising the scientific and technological competence and creativity, and exploration of significant problems."

"Special attention will be given to the development of 'open competence', nurturing of the talent, and creating a climate supportive of scientific and technological creativity through fostering awareness and public understanding of science and technology and their implications."

The Consultation Meeting observed that 'open competence' as viewed by the meeting in the context of science education "refers to empowering concepts and skills which are flexible and applicable to a wide variety of situations, rather than a limited scope."

The Study Group Meeting on Science Curriculum and Instructional Materials Development (Bangkok, November 1981) while discussing the concept of open competence observed: "We are in an age of rapid changes in the natural sciences and social situations. In order to adapt to the rapidly changing and progressing age and to contribute to the socio-economic progress it is important for all the students to acquire certain competences and attitudes to solve problems, processing appropriately fast expanding information and to think creatively. For education to assist in this, school science education programmes will have to provide for teaching-learning experiences through a variety of methods which will help develop concepts and skills which are

flexible and applicable to a wide variety of situations rather than limited in scope." The group suggested the following as an illustrative list of open competence:

a) Process skills (scientific methods):

Observation; Measurement; Recording; Infering; Designing and conducting of experiments; Data interpretation; Making assumption; Formulating hypotheses and testing; Controlling variables and isolating; Formulating models; and Communication skills (including use of symbols, graphs, etc.)

b) Knowledge:

Understanding and using of: Concepts; Laws or principles,formulas, symbols and signs; Knowledge of methodology; and Mathematical skills.

c) Way of thinking:

Deductive; Inductive; Analytical; Synthetical; Divergent; Convergent; Intuitive; Imaginative and Creative: dreaming, playing, initiating, creating.

d) Attitudes:

Self-reliance; Positive self-confidence or self-concept on his/her judgement of ideas (or creations) with respect to science and science learning; Respect for others' judgement and ideas; Patience or tolerance for differences and disagreements from others (or listening to others); Courage and willingness for taking the responsibility for his or her judgement and ideas; Sensitivity to changes and new problems; Awareness of social and national development; and Love for nature as well as human beings.

e) Values:

Seeing science as an important part of our culture; Seeing science as an approach to solve human and social problems; Seeing science as a process as well as a product; Understanding or recognizing science as the creation of co-operative work; Seeing science as a critical factor for the improvement of human welfare as well as the technical development; and Judging on the basis of sound evidence.

Why 'Open Competence'

We are now living in a world where applications of science and technology are increasingly shaping the lives of all the people. Science and technology and their applications are now integral parts of social life and culture, both at the personal and national levels. In the countries of this region also, the interaction between science, technology and society is increasing at a rapid pace. In order to meet the challenges of this rapidly changing and progressing age; to ensure a proper and responsible use of science and technology; and to achieve the goals of development and of improved quality of life, science education has a major role to play in developing necessary competences and attitudes, at appropriate levels, among all the people to help solve real-life problems, process appropriately the ever increasing information, think creatively and make sound decisions on issues and problems which have been or may be created in future by an explosive application of science through technology.

Perceptions of 'Open Competence'

The concept of 'Open Competence' was perceived by the participants of the Meeting in the following different ways in the context of their science education programmes, and socio-economic development efforts:

- Possession of appropriate knowledge, skills and attitudes acquired through science eduction and the ability to apply these in a wide variety of situations.

- Awareness and consciousness of anticipating possible changes, the readiness to meet challenges and the quickness with which to catch up with developments.

- Adaptability achieved through science related experiences, to survive, progress and lead in a constantly and rapidly changing socio-economic and technological environment.

- 'Openness' is associated with the ability to transfer experiences from one situation to another and go beyond the boundaries of science. 'Competency' is the ability to perform efficiently in cognitive, psychomotor and affective terms.

- Ability to synthesize knowledge from different disciplines of science to be able to predict and view the problems of society.

- Ability to use the competences acquired and developed through science education in real life situations.

- Understanding of empowering concepts and skills in science which are flexible and applicable to a wide variety of situations rather than have a limited scope.

- Ability to solve problems in the context of one's own environment and transfer learning from one situation to another.

- Ability to relate and apply science concepts, processes and attitudes to a variety of situations.

- Basic competences, with open attitude of science, which are applicable to a wide variety of situations.

- Open-mindedness and ability to acquire requisite knowledge, concepts and skills in science and scientific attitudes in order to apply these to meet challenges born out of constantly changing situations in the context of socio-economic development.

In view of the above, the fostering and nurturing of 'Open Competence' in a learner, the science education programmes would need to provide knowledge and understanding of empowering (key) science concepts, develop science process skills through first-hand real-life experiences and adopt teaching-learning strategies which would help:

- information processing
- problem solving
- creativity
- decision making
- possession of appropriate knowledge, skills and attitudes applicable in a wide variety of real life situtions
- awareness and consciousness of anticipating possible changes
- readiness to meet new challenges
- quickness to catch up with development
- adaptability to survive, progress and lead in a socio-economic change

- transferability from one situation to another
- ability to integrate knowledge
- sensitivity to problems of society
- flexibility
- basic competences with open attitude of science
- ability to innovate and disseminate innovations
- values clarification

The Implications of 'Open Competence'

The Meeting was of the view that it is neither possible nor desirable to arrive at a common simple definition of 'Open Competence', a complex concept in itself, and particularly in the emerging context of 'science for all.'

It is asumed that learners with open competence would have acquired a growing body of appropriate knowledge, mastered specific skills and been imbibed with some healthy and positive attitudes that they would be able to apply to a wide variety of teaching-learning and living situations.

By implication, such a person would be a life-long learner, sensitive to variations of changes all around him and able to detect and synthesize areas of relevant knowledge from different disciplines of science in order to view and attempt at solving problems of society, including unpredictable ones. He or she would have also developed high-level of open-mindedness to a sufficient level to be able to cope with and to contribute to new challenges born out of constantly changing situations in the context of rapid political, technological and socio-economic developments taking place in each country today.

Open competence could therefore be operationally categorized into an integrated set of competences and attitudes related to the following four major areas:

a) Information processing
b) Problem solving
c) Creativity
d) Decision making

Information processing: As we approach the next century, we would be entering into the 'Information Age'. It is therefore critically important today, in the light of explosion of knowledge in all disciplines, both science and non-science, that we equip our students with competences to cope with the challenges of the

information age and have access to and integrate knowledge from multifarious sources quickly and effectively. Before one can even begin to process information, it is important to ascertain one's information needs or type of information needed.

To process information, in the light of explosion in scientific and technological knowledge, will need the competence to identify empowering (key) concepts and skills of science which are flexible and applicable to a variety of situations.

Problem solving: This is action-oriented. It entails the awareness and consciousness of anticipating possible changes in the human and non-human interactions all around us. It also implies the possession of reliable knowledge, skills and readiness to meet new challenges.

In the context of science education, problem solving is seen as a process where previously learned concepts, principles and skills are applied in a variety of real-life and simulated situations which lend themselves to the application of the various steps of the scientific method.

Creativity: In essence, creativity is closely associated with the ability to perceive meaningful and novel relationships between commonplace objects, ideas and phenomena and to synthesize these into new manifestations or products.

Creative thinking may also be treated as a special kind of problem-solving 1/ to the extent one or more of the following conditions may be satisfied:

a) The product of the thinking has novelty and value (either for the thinker or for his culture).

b) The thinking is unconventional, implying modification or departure from previously accepted ideas.

c) The thinking requires high motivation and persistence, taking place either over a considerable span of time or at high intensity.

d) The problem, as initially posed, was vague and undefined and that part of the task was to formulate the problem itself.

1/ Newell, Shaw and Simon cited in Torrence, E.P. "Scientific Views of Creativity and Factors Affecting its Growth", Daedalus, Proceedings of the American Academy of Sciences. Vol.94, No. 3, Summer 1965, p. 666.

The very basic rationale for the concept of 'open competence' rests on the assumption that the knowledge, skills and attitudes acquired in one situation should readily find application in another either to solve the problem or to generate further ideas.

Decision making: The interaction of science, technology and society brings into focus the increasing importance of decision making competences.

Decision making is the basic determinant of the scope and direction of one's reactions towards the environmental and societal changes. It would necessarily begin with value clarification and proceed to identifying alternatives for action, weighing the possible consequences of each alternatives, ordering these alternatives in the ranking of risks and expected outcomes and finally deciding on the mode and being fully responsible for all consequences that can be expected.

'Open Competence' has thus to be viewed as a complex and integrated concept encompassing various competences and attitudes related to processes of information processing, problem solving, creativity and decision making. The mix of various elements would depend on the science education programmes being followed in different countries, their resources, social ethos and developmental goals.

Chapter Three

COMPETENCES AND ATTITUDES FOR SCIENCE TEACHERS AND SCIENCE TEACHER EDUCATORS

Introduction

It is expected that before the close of the century, all the countries of the region would have achieved the goal of universalization of primary education. Some of the countries would have even extended the duration of universal education to 8-10 or even 12 years of schooling. This implies that all the children in these age groups would be in the formal school system and would thus have an opportunity to get exposed to science and technology related teaching and learning experiences through various science education programmes.

In the above context, the school classes would be more heterogeneous having pupils from all stratas of the society and with varying socio-economic, cultural and natural environment.

In addition, with the rapid growth of scientific knowledge and its explosive applications through technology for modernization of the societies and improving the quality of life, the interactions between science, technology and society are bound to considerably increase resulting in the rapidity of the pace of changes.

To survive in and cope with such rapidly changing environment, school science and technology education programmes will have to meet the challenge by providing access to meaningful knowledge, skills and attitudes to the students through radical changes in curricula of school science and strategies and methodologies for its teaching and learning. Already some thinking has started in this direction within the emerging concept of 'Science for All'.

The science teachers, though in a new and wider role, will continue to be the pivot of the teaching and learning activities in the formal school system for generating meaningful science related knowledge, skills and attitudes and to make the science learnt in the schools more relevant for their pupils by developing open competence to cope with the rapid socio-economic, cultural and

environmental changes brought about by the applications of science and technology. In addition, in this regard, they would have much contributions to make for educating the out-of-school target groups. For this purpose the science teacher education programmes would have to equip the teacher with new competences and attitudes for developing 'open competence' in their students in the wider context of 'Science for All'.

Towards competence-based teacher eduction

In some of the countries in the region, there is a growing shift of emphasis from performance-based science courses to competence-based courses for the training of science teachers. Performances tend to be tailored for specific purposes only, whereas competences are more broad-based and are designed for coping with a variety of fast changing situations in science education.

Whatever the problem, relevant content background is essential in arriving at solutions. Familiarity with such areas as - philosophy, history and sociology of science; social structures and issues; psychology and philosophy of science education; and science education research methodologies - will greatly enhance the development of problem-solving competences and attitudes, particularly the sensitivity to potential problem situations in the classroom, community and the larger society.

The requisite competences and attitudes can be subsumed under four major processes earlier identified with open competence in Chapter Three, namely

- Information processing
- Problem-solving
- Creativity
- Decision-making

Information processing

In the light of the ever-increasing explosion of scientific information inundating all areas of studies, the innovative science teacher of today needs the specific competences to ascertain his or her information needs and the nature as well as the scope of the information needed. The competences associated with information processing are the ability to:

a) identify, locate and utilize sources of information

The sources of information include standard text-books, library resources, computerized programmes,

community resources (e.g. information materials distributed by government and private agencies and industrial enterprises, resource persons), the various forms of mass media, covering television, radio, video; and his or her own real work place experiences and understanding.

b) classify, analyze and utilize relevant information.

In collecting and recording information, basic skills, like classifying facts and concepts, making abstracts, annotations and bibliographies are essential. The teacher must also be familiar with acceptable format for noting, filing and reporting information. It is necessary for all sources of information to be acknowledged.

c) simplify scientific information from primary sources to the level of the target group

It is insufficient to rely entirely on the factual information prescribed in a text material. The teacher should have the competences to extract and simplify scientific information from journals, research reports and other sources to the level of the students. This will entail selecting, deciding on scope and nature of content and re-writing the materials, or translating into appropriate languages, so as to bring it to the cognitive level of the pupils.

d) be familiar with the use and application of newer technologies.

With the availability of multitudes of hardwares and softwares of the newer technologies for processing and presenting information the teacher must also have some familiarity of the use, application and simple maintenance of the technologies wherever available. Those would cover such equipment as the computer, video and audio recorders, film and slide facilities, etc.

Problem-solving

In the context of science education, problem-solving usually entails performing the steps of the scientific

method. Problem-solving[1/] is as a process where previously learned rules and concepts are applied in finding solutions to a variety of real-life and simulated situations which lend themselves to the application of the scientific method. It is to be recognized that some problems may require scientific experimentation, while others may need only a theoretical or mathematical treatment. The competences and attitudes which need to be developed in science teachers/ educators for developing problem solving are:

a) sensing, recognizing and defining the problem.

Developing certain competences and attitudes will enable the science teacher or science teacher educator to solve the problems confronting him. In sensing a problem for instance, he must be able to identify possible sources and causes of problem, such as those arising from the content taught, teaching strategies, pupils, and teachers. Science-related problems, for example, may be brought to the attention of the teacher by the student as a result of the latter's readings and experiences outside the school. A deirable attitude on the part of the teacher is willingness to help the student and allow these problems to be studied and solved in the classroom.

b) hypothesizing.

Similarly, hypotheses must be formulated in an open atmosphere conductive to free expression of novel, unorthodox and orginal ideas. Hypothesizing would constitute the first attempt at constructing a logical possible answer within the available information and established framework. The testing of hypotheses requires competences like designing experiments and examining data againt supporting evidence.

c) determining the type of study.

The manner in which the study is to be undertaken is largely dependent upon the nature of the hypothesis made and the extent of the subject, the population or the target sample. The type of study could be experimental, survey or just literature analysis. The nature of the sources of the information or data would also determine the type of study.

1/ Kempa, R.F. and Nicholls, C.E., 1983, Problem-solving Ability and Cognitive Structure - an exploratory investigation, European Journal on Science Education, 1983, Vol. 5, No. 2, p. 171.

For problems requiring experimentation, laboratory skills such as the following would be needed:

1. Application of various appropriate laboratory procedures and techniques, including safety measures.

2. Use, maintenance and simple repair of equipment, instruments and facilities available in the school laboratory.

d) judging the adequacy and accuracy of information and data.

For any study to produce valid results, the amount of the information or data collected should cover a scope of targets and sources so as to leave no significant areas oflack which can possibly lead to vagueness in the nature of the information. The type of instruments used and the manner of administering the instruments would determine the accuracy of the data. Research findings not based on adequate and accurate data would not command respect and acceptance.

In making generalizations, the science teacher/ educator is expected to be able to form conclusions based on the results, recognize the limitations of the data and tentativeness of the findings, draw implications, and determine the scope of applicability of the results.

e) communicating results of the inquiry.

In order to share new information obtained, the teacher/educator needs the skill to effectively communicate the process and the results of the inquiry in oral as well as written form. Should there be important areas of lack perceived in the findings, these should also be made known to others so that they might continue investigations along similar lines.

Creativity

Educators and psychologists have grappled with the attributes of creativity. However, creativity has not received as much attention in science education as problem-solving.

Normal children by their very nature are curious and the teaching and learning of science has rich potentials to

encourage and develop this trait. It is curiosity that is the main driving force for 'creativity'. Episodes from the history of science and technology amply demonstrate that curiosity has been the main source of discoveries in science and technology. Science teachers have therefore an important role to play in fostering and sustaining the natural curiosity which is an attribute of young children, and thus leading them to creativity. For this purpose the teacher training programmes will need to include experiences which will help develop necessary competences and attitudes needed for fostering and sustaining of these traits. An authoritarian, insensitive attitude and fear of criticism on the part of science teachers can easily thwart the fostering of creativity amongst their pupils.

The Meeting noted that a recent study[1/] has concluded that the creative people exhibit the following behaviours:

- challenge assumptions
- see in new ways
- recognize new patterns
- make new connections
- construct new networks
- take risks
- take advantage of chance

The creative individual is also seen as one who:

- exhibits high-level curiosity
- thinks originally, flexibly, divergently, imaginatively
- is able to elaborate
- is able to improvise, innovate and invent

Furthermore, the creative person has the sensitivity to situations leading to the aforementioned characteristics. The competence that would help science teachers/educators to promote creativity would include the ability to:

a) <u>identify creativity-promoting settings from local situations</u>

The science teacher/educator needs certain competences and attitudes to foster creativity in the

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1/ Baez, Albert. Curiosity, Creativity, Competence and Compassion - Guidelines for Science Education in the year 2000. World Trends in Science Education, ed. by Charles McFadden, Halifax, Nova Scotia, Canada: Atlantic Institute of Education.

students as well as make it an integral part of his thinking and behaviour. From local situations and the immediate environment, he must be able to identify common toys and gadgets and science-related experiences and use them to help students discover underlying science concepts and principles. One way to facilitate making new connections is for the teacher to identify local situtions and happenings, environmental and social issues of multi-disciplinary nature that can be discussed in the classroom. To construct new networks, the teacher must have the competence to synthesize ideas and use simple techniques of systems analysis within and across the disciplines.

High-level curiosity is demonstrated, for example, by the ability to ask probing, analytical, open-ended questions when faced with a novel situation or strange phenomenon. Elaboration requires the competence of giving several alternatives, making several observations and explanations of a situation or phenomenon.

b) identify and utilize episodes from the history of science

Another useful teacher competence for encouraging creativity is the ability to identify and describe instances in the history of science where challenging assumptions and taking advantage of chance led to discoveries. The history of science also shows how great scientists like Galileo and Darwin took risks in proposing ideas contrary to established or prevailing beliefs. A creative person is willing to take some amount of risk in introducing changes or presenting new ideas.

c) identify unsolved problems and problems with multiple solutions

A useful skill is to be able to collectively encourage students to identify unsolved problems as well as problems with multiple solutions, especially those that involve values, and beliefs affecting human and social affairs. Students could then be encouraged, through brainstorming activities, to come up with ways of studying and seeking solutions to these problems. Moreover, as children have their own perceptions and views concerning science ideas and phenomena around them, these can lead to numerous learning situations where ideas may be tested, revised or discarded. In this way facts, concepts and principles acquired by

children, as a consequence of modifying their own perceptions and science ideas would be of a more lasting value and use.

d) design and provide learners with investigative type of learning episodes

To promote divergent thinking in the classroom, the teacher must also be able to design investigative type of learning activities where the outcomes of the studies may not be so easily predictable. The elements of surprise and expectation involved would contribute much to motivation and prolonged sustenance of effort. Too often, school science teachers tend to present problems with set solutions, usually one solution only.

e) identify and utilize issues of multi-disciplinary nature for classroom discussion

Issues relate to sets of established beliefs concerning the right and the wrong as well as the good and the bad. These can arise in the local environmental or social context, not necessarily enumerated in the regular textbooks. A good teacher need competence to capitalize on these issues and create interesting and meaningful learning situations.

f) take calculated risks

Any exploration into the new and the unknown always involves appreciable elements of risk, either physical, intellectual, emotional or social. Creativity involves risk. Many great discovers had to undergo great ridicule and shame before due credits were given. The scope and the nature of the risk to be taken depends on the performer's imagination, personality and creativity.

g) synthesize ideas and apply techniques of systems analysis

The competence of creativity implies the ability to put together divergent or apparently unrelated ideas into forms that generate thought, newer ideas and a sense of achievement that cannot normally be achieved through replications of tried and tested procedures. A mastery of the techniques of the systems approach should help the teacher to plan his strategy more logically.

h) ask probing, analytical and open-ended questions in order to arouse curiosity

The creative science teacher need to have the competence to formulate penetrating questions that demand analytical and synthetical type of thinking if open-ended investigations are to be encouraged. Curiosity, if properly nurtured can lead to sustained actions and tend to give rise to more curiosity as new challenging grounds are perceived by the motivated learners. The belief that there are other hidden alternative solutions or explanations to be discovered around the next corner of the learning episode is in itself a powerful motivating factor in science learning.

Decision-making

The interaction of science, technology and society has brought into focus the increasing importance of decision-making competences and attitudes for teachers and students. Many decisions are made at the community, national or international level involving the application of science through technology, e.g., construction of power plants; use of pesticides, herbicides, food additives; nuclear weapons; pollutants from industries, which may have far-reaching, long-term societal implications in terms of health, economic, political and cultural consequences.

Yet some of these decisions are made without following the steps of rational decision-making, namely:

1. Selecting reliable information and clarifying values
2. Identifying alternatives
3. Predicting the consequences of each alternative
4. Weighing the pros and cons of each alternative
5. Ordering the alternatives
6. Taking actions consistent with the stated values
7. Accepting possible consequences of the actions taken

That rational decision-making is essentially scientific inquiry, strengthens the case for developing decision-making competences and attitudes in the science class.

Some competences for rational decision-making which need to be developed in science teachers/teacher educators are:

- Recognizing the social consequences and responsibilities of the development of scientific and technological possibilities.

- Objectively appraising available information and rationally analyzing the long-term environmental and social consequences of alternate possibilities for action or restraint.

- Communicating the consequences effectively and with urgency for gaining public attention to significant decisions.

- Teaching applications of science through technology in society in such a way that pupils are helped in forming defensible opinions on science-related societal issues.[1/]

- Fostering pupils' growth in decision-making in a participative manner.[1/]

- Seeking connection between science and technology in science lessons.[1/]

In collective decision-making, an additional competency is the ability to use group dynamics and human relation skills. Respect for the opinions of others and of the group decisions without necessarily agreeing with them is important. In the classroom situation, the teacher must have the ability to guide students to make their individual and collective rational decisions, rather than merely adopt the teacher's position or decision on the basis of fear or authority. It is also helpful for the teacher and students to acquire knowledge on how actual decisions in life at the personal, community or national level are made and be able to compare the methods and processes of these decisions with rational decision-making.

As in creativity, inherent risks are involved in making a decision, willingness to take risks and firmness of decisions are therefore attitudes to be encouraged.

The four major elements of open competence -- information-processing, problem-solving, creativity, and decision-making -- overlap and interlink. Information-processing is needed in the three other elements which all require a knowledge base. Problem-solving competences

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1/ Holford, Derek G. Training Science Teachers for "Science-Technology-Society" Roles. Preservice and Inservice Education of Science Teachers. ed. P. Tamir et al. Rehovot. Israel: Balaban International Science Services, 1983.

such as those used in interpreting data and generalizing facilitate making new patterns, connections and networks. Conversely, creativity is needed in problem-solving to arrive at novel or alternative solutions. A certain amount of decision-making is involved in problem-solving as in evaluating the adequacy and accuracy of data, and in rejecting or not rejecting a hypothesis. The interrelatedness of the elements must be considered in developing the competence.

Chapter Four

STRATEGIES FOR DESIGNING AND DEVELOPING SCIENCE TEACHER EDUCATION PROGRAMMES AT THE PRE-SERVICE, IN-SERVICE AND CONTINUING EDUCATION LEVELS WITH FOCUS ON OPEN COMPETENCE

Introduction

Curricula of science at all levels are increasingly taking on new dimensions so as to enable a learner attain sufficient competence to cope with the changing society.

Some factors that have brought about changes in society are: increased educational requirements for almost all jobs; changing value systems; community problems; a growing alienation of the youth from the society; explosion in scientific knowledge, and extensive applications of science through technology. Because of these changes, a science teacher is now expected to assume new roles such as that of facilitator, decision maker and problem solver.

The challenges cannot be met by present science teacher education programmes which emphasize pedagogy and content more than the acquisition of competences. It is therefore imperative that pre-service service science teacher education and teacher educator programmes be redesigned to meet the challenges.

The pre-service programme

A. Elementary and Secondary Teacher Education Programme

The science teacher eduction programme should be designed to: (a) provide a full liberal education; (b) prepare a useful citizen and responsible leader in a society influenced by science; (c) prepare a proficient and knowledgeable teacher of science with stipulated competences and attitudes as mentioned in Chapter Four and who is confident of his professional role and of the importance of what he does for society.

The basic curriculum of science teacher education should include (a) sound liberal education through mastery of content;

(b) knowledge and awareness of interrelationships of science, technology, society and culture and the development of the history and philosophy of science; (c) knowledges and skills pertaining to characteristics of learners, techniques and practices in science teaching; and, (d) basic skills in science education research.

The proposed programme includes three broad areas: professional education, content and liberal education. The following diagrams show the percentage for each area for the primary/elementary and secondary levels:

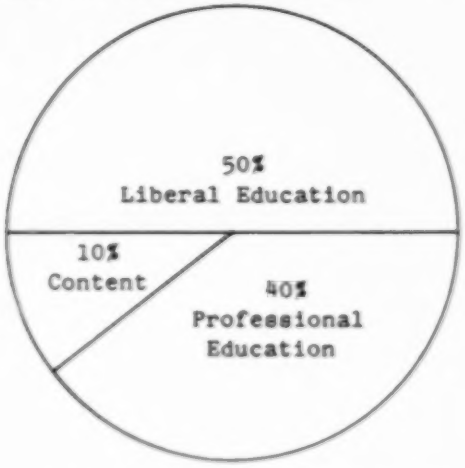


Figure 1. Elementary Education Programme

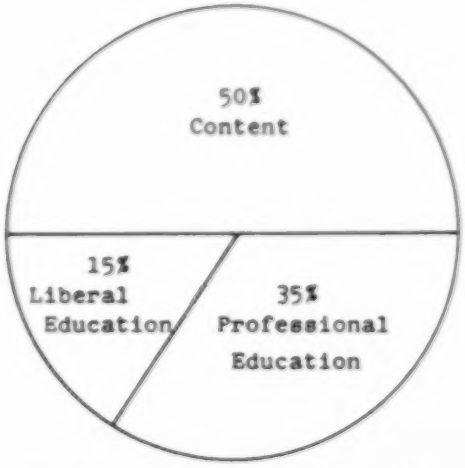
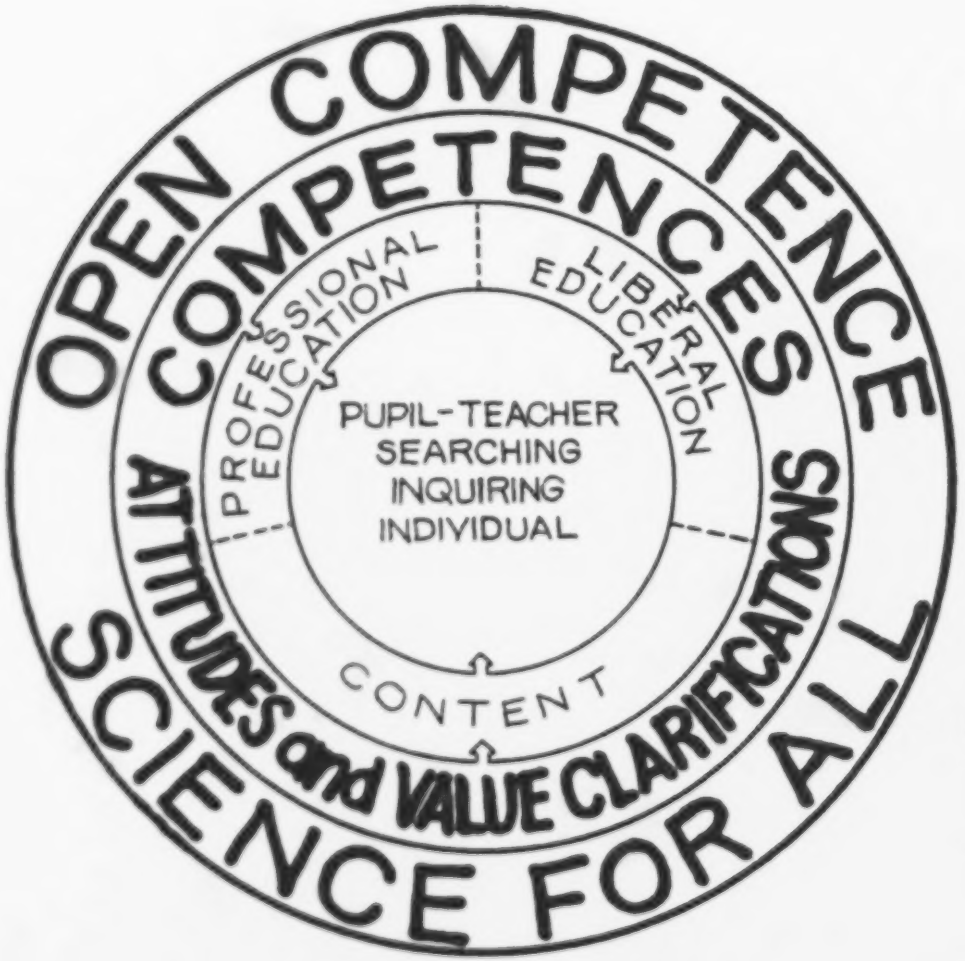
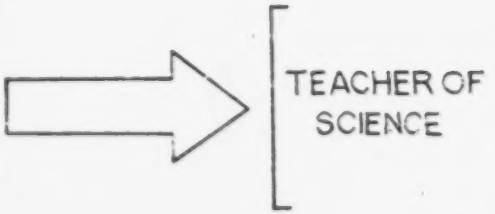


Figure 2. Secondary Education Programme





LEGEND:
------NO BOUNDARIES AMONG THE THREE AREAS
⟹ THE INPUTS TOWARDS THE PUPIL-TEACHER

FIG. 3 PROPOSED TEACHER-EDUCATION MODEL

Training of science teachers and teacher educators

Professional education relates to the philosophical, sociological and psychological foundations of eduction, as well as the methodology, theories and principles of science teaching.

Liberal education includes the social sciences, humanities as well as language, with focus on communication skills and mathematical skills.

The content area covers the history and philosophy of science, science concepts and principles, and laboratory experiences.

Figure 3 is the proposed teacher education model. The target is the pupil-teacher who is a searching and an inquiring individual. The inputs are the competences, attitudes, and value clarifications developed simultaneously in the areas of professional education, liberal education, and content. The expected output will bring about the open competence to deal with programmes such as "Science for All".

Suggested programme of study

Figure 1 and 2 can be translated into a concrete programme of study as suggested in Table 1.

Table 1. Suggested Programme of Study

Areas	Elem Sc. Teacher Educ. Programme	Secondary Sc. Teacher Educ. Programme
1. Science content -	10%	50%
History and philosophy of science Science, technology and society Science concepts and principles Laboratory work		

Table 1 (Cont.)

Areas	Elem. Sc. Teacher Educ. Programme	Secondary Sc. Teacher Educ. Programme
2. Professional Education	40%	35%
Science education - Psychology of learning science; Science content and methodology of teaching; Laboratory techniques; Educational technology; Evaluation in Science education; Curriculum and instruction; Science education research	10%	25%
Student teaching/ internship	15%	
Foundations and other education courses	15%	10%
3. Liberal Education	50%	15%
TOTAL	100%	100% 100%

A brief discussion of some of the components of the programme of study follows.

1. History and Philosophy of Science. History in this course must emphasize contributions of the scientists and more so on scholars of the region in general and the country in particular. The focus should be on the historical development of scientific theories - as to how they transformed man's way of life and thinking about natural phenomena rather than on chronological facts. The philosophical aspect should deal with the nature and methods of science including its humanistic aspects.

2. Science, Technology and Society. This course should be geared towards understanding the relationship between science, technology and society. It should be designed to develop the

interest, competence, confidence and the willingness to continue to keep abreast of the scientific and technological development in areas related to societal concerns of the community and the country. Further, it should allow the recognition and understanding of the social and environmental implications of scientific and technological advances. The benefits derived from the proper use of scientific and technological development and the consequences of misuse of these developments should be stressed.

3. Science Education Courses. Science content and methodology should be tackled in an integrated manner. The goals and objectives of science education should be highlighted. Research skills and awareness of the recent developments could lead to improvisations and innovations in science teaching. Actual classroom teaching experiences should be included to translate theory into practice.

4. Laboratory Techniques and Skills Development. This course should provide opportunities to perform and apply the processes of science as well as manifest scientific values and attitudes. The ability to perform basic laboratory procedures, proper use of laboratory equipment, observe laboratory safety measures and perform emergency procedures are expected competences. The laboratory skills should be developed to enhance rational thinking.

5. Educational Technology. This course should stress the application of the principles, methods and tools of educational technology to enhance understanding of concepts, develop teaching skills, evaluate the effectiveness of science teaching and assess student achievement, including basic elements of computer literacy.

6. Science Courses. The choice and level of these courses should be determined on the basis of the entering competences, the field of specialization, and the level of preparation (elementary science teaching, secondary science teaching, teacher education) required by the student.

7. Foundation Courses. The discussion of theories and principles in these courses should be relevant to the teaching learning of science for developing open competence.

While recognizing the importance of the foundation courses, it is felt that such courses are over loaded with concepts and principles which do not easily lend themselves to the learning of science particularly in the context of open competence. It is therefore suggested that a re-examination of these courses be undertaken to make them relevant to the objectives of science for all.

Structure and Sequence of the Programme

The structure and sequence within the three broad areas are shown in Table 2 for the training of elementary/primary level and Table 3 for the secondary level science teachers.

Reference should be made to Figures 1 and 2 regarding the distribution of percentages of weightage for the three broad areas and to Table 1 for the suggested cluster of course offerings.

Table 2. A Proposed Four Year Elementary Teacher Education Programme: Structure and Sequence

Development and Refinement of Competences and Attitudes				
	Prof. Ed. I	Prof. Ed. II	Prof. Ed. III	Prof.Ed. IV
Professional Education	Psychology Principles of teaching	Psychology of learning Science methodology Educational technology	Student teaching Measurement and evaluation	Intrdocution to research
Practice Teaching	Observation	Aide to teachers	Student Teaching	Internship
Content	Content I Science	Content II Lab skills and techniques	Content III History and philosophy of science	Content IV Science technology and society
Liberal Education	Liberal Educ.I Humanities	Liberal Educ. II Communiction skills Computational skills		
	1st year	2nd year	3rd year	4th year

The elementary/primary programme structure and sequence in Table 2 is meant for four years. However, with the constraints in human and material resources, finances, etc., it is left open to the respective countries to modify the proposed four year programme into a two or three year programme.

Table 3. A Proposed Four Year Secondary Science Teacher Education Programme: Structure and Sequence

Professional Education	Prof.Ed. I Psychology of learning Educational technology	Prof.Ed. II Science content and methodology Measurement and evaluation	Prof.Ed. III Student teaching	Prof.Ed. IV Introduction to research
Practice Teaching	Observation	Aide to teachers	Student teaching	Internship
Content	Content I Science concepts and principles including Lab work	Content II Science concepts and principles Lab work	Content III Science concepts and principles Lab skills and techniques	Content IV History and philosophy of science Science, technology and society
Liberal Education	Liberal Educ. I Communication skills Computational skills Humanities, social sciences	Liberal Educ. II Communication skills Computational skills Humanities, social sciences	Electives Applied science courses related to the field of specialization	Electives (Courses outside of the field of specialization)
	1st year	2nd year	3rd year	4th year

Figure 4 shows the suggested distribution of percentages for the three broad areas for a two year programme.

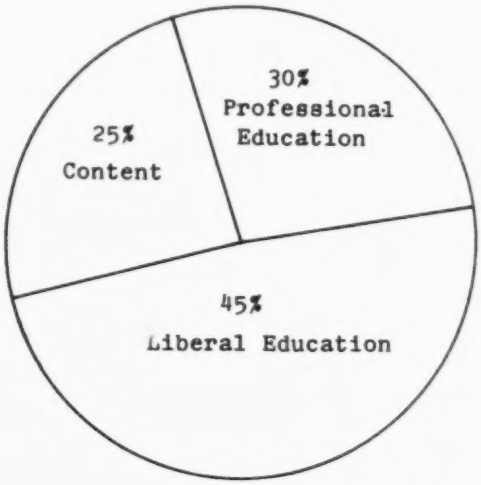


Figure 4. Proposed Elementary Education Programme (Two years)

To implement this distribution, Table 4 shows the structure and sequence for a two year programme.

Table 4. A Proposed Two Year Elementary/Primary Teacher Education Programme: Structure and Sequence

Development and Refinement of Competences and Attitudes		
	Prof.Ed. I	Prof.Ed. II
Professional Education	Psychology of learning Principles of teaching Science methodology	Student teaching Measurement and evaluation Educational technology
	Content I	Content II
Content	Science Laboratory skills and techniques Mathematics	History and philosophy of science Science, technology, and society
	Liberal Ed. I	Liberal Ed. II
Liberal Education	Communication skills Computational skills Humanities	Communication skills Social sciences Humanities

Training of science teachers and teacher educators

Depending on the state of the art, a number of countries are in a period of transition from a two to a four year teacher education programme.

The Meeting strongly recommends that there should be at least a two year professional training programme and countries should attempt to move in steps towards a four year integrated programme of content and pedagogy for teacher education, in both elementary/primary and secondary levels.

Some strategies for implementing the programme

With regards to teaching strategies and techniques every effort should be made to allow for individual differences among the trainees. Instruction must be planned so that they may progress at different paces and by giving advance credits in completing programme requirements even before entering college or through informal experiences during college.

Wherever and whenever feasible, practical experiences should be an integral component of the courses. Instructional strategies recommended for use in actual classroom situations should be demonstrated and utilized as these student teachers will later on teach the way they were taught. Experienced teachers in schools with specific competences could be utilized as co-operating teachers.

The student teachers should be provided with opportunities to design, develop and evaluate learning experiences appropriate for specific groups of pupils to achieve identified objectives. One such activity is to ask them to assess the science curricula in schools to ensure that illustrative phenomena are selected not simply because they support a given concept but because they are of practical use and of everyday interest and the concept presented must be within the cognitive level of the pupils.

To develop laboratory skills and provide opportunities for the practice of science processes, laboratory equipment, hand tools and workshop facilities should be provided. These facilities should allow for the performance of predetermined exercises and open-ended experiments.

The trainee should gradually be inducted into the teaching profession. He starts as an observer of classroom settings, to teacher aide and then as student teacher and finally, as an intern involved in actual teaching and other aspects of school management.

Evaluation of the proposed pre-service programme

Evaluation should aim at improving the training process, the trainees, the curriculum, as well as the evaluation processes itself. The subjects for evaluation may be the competences and attitudes of trainees, the curriculum, and the practitioners in the field.

Evaluation may be internal or external. Internal evaluation is done by those who are involved in the programme itself. Trainees may be evaluated in terms of the stated competences. The programme may be evaluated in terms of how much its objectives are met. On the other hand, external evaluation may be done by comparing the effectiveness of the programme with other existing programmes. Evaluation may also be done by a body apart from those directly involved in the programme.

Here are some evaluation techniques which could be implemented:

1. paper and pencil evaluation of and by students
2. student reaction surveys
3. teacher profile (during pre-service training)
4. frequent observation of the student teachers in the field by the teacher trainers in the colleges
5. comparison of the curriculum materials, and outcomes of programme with other existing programmes
6. frequent meetings and joint evaluation projects among teacher training institutions and policy-makers
7. evaluation by other agencies not directly involved in the programme by way of observations, surveys, tests, etc.

B. The Science Teacher Educator Programme

At present science teacher educators are being drawn from faculties of science and faculties of education and experienced science teachers from schools to deal with the various related components of teacher education curricula. However in view of the demands of the new teacher education curriculum there is a need to develop a new breed of teacher educators - the Science Teacher Educators, who are not only proficient in science, but in applying educational theories to science teaching as well as in developing and designing new theories and innovative techniques of science education.

Training of science teachers and teacher educators

The qualifications of most of the present science teacher educators are any of the following mix: B.Sc. + M.Ed.; M.Sc.+ M.Ed., BSE + MS, BSE + M.Ed. They are not products of formal science education programmes.

To ensure the development of new type of qualified science teacher educators, the Meeting deemed it necessary to develop a science teacher educator training programme which will draw its strength from the discipline of the sciences and education.

It is envisioned that the future science teacher educators should possess proficiencies in (a) science, (b) pedagogy, and (c) research.

1. Science Content:

   - Introductory courses in the basic sciences (physics, chemistry, biology, earth science) including energy and environment education at the college level.
   - Workshop and laboratory experiences
   - At least B.Sc./M.Sc. level in one field of science
   - Scientific research exposure/experience
   - Philosophy, history and sociology of science

2. Science Education:

   - Philosophy and history of science education
   - Science curriculum and instruction
   - Theories on the learning and teaching of science
   - Laboratory procedure and techniques
   - Evaluation in science education
   - Actual classroom teaching
   - Research methods, statistics and computer science

   Science education research and development

   - Knowledge of research designs
   - Using statistical techniques and the computer in data analysis

3. Foundations of Education

   - Sociological, philosophical and psychological foundations of education

Translated into a programme for science teacher educators, the foregoing areas of proficiency were given the following weightages:

1. Science Content 35%
2. Science Education 35%
3. Foundations of Education 10%
4. Electives - from areas 1, 2 or 3 above ... 20%

To effectively implement the programme it is recommended that strong linkages on an institutional basis be developed among the faculties of Sciences, Education and other relevant agencies to provide the science teacher educators with a wide range of competences in the sciences, pedagogy, research and in other related areas (e.g. engineering, computer, etc.). It is only through this multiple interaction that a new generation of competent science teacher educators will emerge.

This science teacher educator programme will generate the new breed of science educators who can be employed as science education professors in colleges and universities, research and development staff and curriculum developers in science education institutions and centres and policy-makers and administrators and supervisors of science education. They, together with the science faculty and the education faculty should share the responsibility for pre-service and continuing education of science teachers. These science educators should also be responsible for the development of science education programmes in all levels.

In-service and continuing education

The two closely related concepts of in-service training and continuing education were considered in the context of training of science teachers on a continuous basis. Although the two concepts, as they have emerged, could be interpreted differently in some situations, the necessity and continuous nature of retraining of science teachers, because of the very nature of science, rapid expansion in its both knowledge and explosive rate of its application through technology, would tend to merge the two into one over-riding concept of continuous on-the-job training for science teachers. Such a training would be necessitated because of gaps and limitation of pre-service training, continuous changes in curriculum, methodology, techniques, innovations and other developments in science education as they take place from time to time.

The Meeting considered the existing practices of in-service and continuing education in the participating countries in the context of developing open competence and mounting programmes such as science for all and suggests that these should be viewed as an

essential complement to pre-service training programmes and that existing practices do not necessarily yield the results expected of these programmes.

The in-service and continuing education programmes are particularly significant in view of the expected and desired competences and attitudes which need to be developed in science teachers. The character, nature and duration of such programmes should aim at developing the knowledge and skill base and attitudes of teachers to enable them perform effectively in the rapidly changing situations.

In-service training programmes, as at present, are mostly centralized and present considerable operational problems. Further, such programmes are usually of rather a short duration and hence, at best help to alleviate immediate problems. To be more effective,such programmes should be spread over longer periods or conducted on a continuous basis.

Following is an illustrative list of programmes, currently being conducted in the countries of the region, which could, with modifications, be more widely implemented in more countries and some new directions added to meet the new challenges:

1. Distance learning is a pragmatic and cost-effective method for upgrading the academic and professional qualifications of science teachers thus providing for vertical mobility for career advancement. The various media used for this could be a mix of radio, television, training modules, correspondence programme.

   Distance education could also be used to keep teachers posted with recent developments and also allow for remedial measures to make teaching-learning processes more effective and purposeful.

2. Sandwich programmes. Knowledge-base of science is expanding at a very fast pace and initial university education is hardly sufficient to meet the challenges posed by this problem. Sandwich programmes are in-service projects which are deliberately planned for serving teachers to update their knowledge bases and competence without leaving the classes or breaking their service. It is therefore imperative that sandwich programmes are launched in the universities, teacher colleges to keep the teachers posted with development and to allow them improve qualifications.

3. School-based in-service training. Depending upon the resources, it might be desirable (as is done in Republic of Korea) to have a highly qualified headmaster/ principal, or may be even a competent deputy headmaster/ vice principal with science background, so that aside from routine administrative responsibilities, he takes on professional development programmes of his faculty or collectively in a cluster of neighbouring schools. This would ensure an in-built mechanism of in-service training.

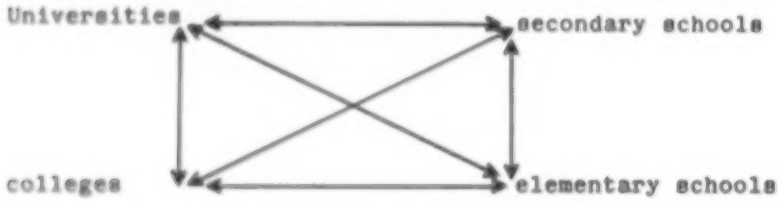
4. Use of school clusters. A number of schools may be clustered around a central school, having the necessary infrastructure in men and material, to assist science teachers in cluster, to solve problems encountered in everyday teaching. The central school would function as a resource base and the schools clustered around it would be such that these are located within easy distance of the central school. This strategy will provide on-the-spot remedial solutions to teaching-learning problems on a continuous basis.

5. Science Resource Centres. Curriculum of science teaching, at the school level, should mainly be activity-based. Lack of appropriate facilities in majority of schools do not permit carrying out activity-oriented experiments. Establishment of science resource centres at district or even lower administrative levels would facilitate such activities. These centres should also have a library and other modular learning facilities to permit self-development of teachers and thus add on to their knowledge base and skills.

6. Teacher Associations. Science Teacher Associations could play a positive role in promoting and enhancing teacher competences. Teacher associations in the Philippines are fairly active and besides having annual conventions, also publish journals to highlight issues, problems and specific strategies concerning instruction of sciences at various levels. Teacher associations, on more or less similar lines, should be formed in all countries and provided with support from the government. Regional and even local branches of these associations should also be encouraged to promote continuous dialogues among teachers on matters concerning their professional growth.

7. Linkages with institutions of higher education. The constantly changing scenario of science education would

require strong linkages between one and the other tiers of education. Such linkages could work to the mutual advantage of all:



Multiple linkages, as in above, will permit exchange of experiences, information, awareness and solution of each other's problems and thus improve classroom performance of science teachers.

Linkages of this type will also develop a sense of partnership between universities, colleges and schools to develop the much needed professionl brotherhood and helping each other to grow professionally.

8. Mobile training squads. Mobile training squads, comprising competent science teachers, should be organized to visit schools and offer specific on-the-spot training and orientation to primary school teachers. Likewise, mobile squads of university teachers could be called upon to provide continuing education to secondary school teachers.

9. Spare time education. Continuing education of underqualified teachers can also be brought about through the process of learning-while-teaching. A teacher can participate in educational activities in his spare time by attending workshops and similar programmes conducted locally, out of his normal teaching hours.

10. Science-on-wheels. Most of the schools in the region lack adequate laboratory facilities in the schools. A "science-on-wheels" facility in the form of charts, models, experiments and low-cost improvisations would allow teachers of such schools to improve their teaching and also provide learning experiences to the students.

Activity-oriented training programmes should be launched to focus on developing the following competences in the teachers:

1. Readiness to accept and adopt a change. Readiness to adopt a change implies elements of exposure, curiosity,

exploration, recipiency and motivation. Activities should be devised to foster and develop flexibility, reduce defensivenes in attitudes and an open-mindedness to the views of others.

2. Divergent thinking. Teaching can be more effective if divergent thinking is developed among teachers through appropriate continuing eduction activities. This will liberate teachers from their one-track thinking and allow them to perceive and consider for adoptation ideas or situations from various incompatible frames of reference.

3. Disseminating process of an innovation. The competences expected of a science learner evolve largely on his ability to improvise and innovate upon existing practices. A teacher has to have the desired competences and also the ability to disseminate the process of innovation. Innovation is a dynamic process; therefore this capability will have to be developed on a continuous basis.

4. New interdisciplinary courses, should be developed for science teachers to extend the scope of science and to make it more relevant to students. Study of sciences should not be confined to preparation for further scientific studies only, but should also prepare students to understand and make informed decisions in ever increasing science-based character of our society.

Need to create institutional mechanism for in-service teacher education

The nature and scope of the programmes, described above, is suggestive of creating and strengthening strong linkages between universities, science and technology organizations and industry on the one hand and teacher training institutions and teacher organizations on the other. It also rests on full moral as well as some financial support from government agencies. It is only then that effective programmes could be mounted on a continuous basis. One strategy is that an independent academy, institution or agency should be created to cope with the multi-dimensional aspects of such programmes. The proposed academy or agency will mobilize its expertise from universities, science and technology organizations, industry and other concerned agencies and thus provide a strong and effective vehicle for keeping the science teachers posted with new developments in content, techniques, processes, innovations and applications of sciences.

Incentives to science teachers

Science teaching is increasingly becoming a highly specialized activity. Pre-requisites, demands and competences expected of a science teacher are overwhelming. A science teacher has to keep himself updated with frontiers of science to meet the challenges posed by his profession. It is therefore important that suitable incentives be provided, particularly to those who show good performance in on-the-job training programmes and contribute positively to the teaching-learning process. Such incentives will encourage the development of competences and attitudes so essential for a competent science teacher.

Incentives could take on different forms. A few suggestions are presented:

1. Best Science Teacher Award be constituted and conferred at the national level, annually for elementary, secondary and tertiary level science teachers. Such awards could also be conferred on sub-regional and even regional level.

2. Best Award for designing an innovative experiment or technique may be conferred annually again on national level for outstanding contribution adjudged through science fairs organized throughout the country.

3. Teachers may be encouraged to write teaching modules, and even monographs, on various aspects of science education. The outstanding contributions should be printed and distributed nationally and due royalties paid to developers.

4. Teachers should be encouraged to do research on science education problems and incentives in the form of research grant and sabbatical leave should be provided.

5. Science teachers are usually exposed to hazardous materials and situations. They are more actively involved in student activities and as such have responsibilities beyond those of an ordinary teacher. It is therefore desirable that a special science allowance or other safety measure provision is given to science teachers as a part of their monthly salary.

6. A teacher normally moves up the ladder during his service career. It so happens that the majority of the higher-up posts have an administrative structure and in the process a compotent science teacher is lost. It

is therefore suggested that competent science teachers should earn their promotion in the normal manner and even on a personal-to-holder basis and allowed to retain their teaching positions.

7. Promotions of teachers should be determined, among other things, on their having attended and of having performed reasonably well in on-the-training programmes.

Chapter Five

SUGGESTIONS FOR FOLLOW-UP ACTIONS

In the light of the review of the existing state of the arts in respect of training of science teachers and teacher educators (Chapter One), the type of competences and attitudes that need to be developed (Chapter Three),and in order to facilitate the implementation of the proposed strategies (Chapter Four), the Meeting suggested the following as some of the follow up actions that need to be supported:

1. The participants of the Meeting should disseminate amongst the teacher educators and policy-makers, the main concerns and suggestions embodied in the report by preparing suitable abstracts.

2. The participants should, as a beginning, attempt to introduce on a experimental basis whatever components of the recommendations they can implement within their existing situation. The results of such experimentation should be made available to ACEID for wider dissemination.

3. The participating countries may organize a national level symposium to debate on the important aspects of the report of this Meeting, particularly with respect to the concepts of 'open competence' and 'science for all' and their implications for the training of science teachers and science teacher educators and develop the outline of a national action plan. For this purpose ACEID should provide support in the form of financial assistance and services of one or two resource persons from other countries whose experiences are considered to be relevant.

4. Member countries should organize Advanced Level Workshops for Science Teacher Educators to critically examine the various suggestions made by this Meeting and which of these can be implemented within the existing framework; to specify in greater details the specific competences and attitudes to be developed and the type of training materials that would need to be developed in this regard. ACEID should provide financial support and services of resource persons, if requested by the countries, for organization of such workshops.

5. With a view to provide direction for developing new courses such as 'History and Philosophy of Science' and 'Interaction of Science, Technology and Society' ACEID should assemble a Task Force for the purpose and disseminate its thinking on the subject. In addition it should also collect and disseminate information on courses in these areas and encourage and support interested associated centres and innovative national groups and science teacher associations to prepare relevant trial materials for teaching such courses.

6. Member countries should plan, encourage and execute research and development projects, particularly in vital areas of science teacher education. Such projects could be carried out on a regional basis to provide much needed depth and replicability.

7. ACEID should collect and disseminate information materials and research findings in respect of development of teacher competences to the participating countries.

8. A study group meeting may be organized to elaborate on evaluation of science teacher competences and attitudes in the context of open competence and science for all programmes.

9. ACEID should encourage and facilitate the exchange of science teacher educators as resource persons among the participating countries to assist countries in organizing their in-service training programmes for development of new competences and attitudes in science teachers for promoting open competence.

10. ACEID should organize more training workshops to further develop the interdisciplinary concept of science teaching, laboratory techniques and improvisation of school science equipment.

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Annex I

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RELATING TO SCIENCE AND TECHNOLOGY EDUCATION

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* *Linking science education to real-life experiences and related productive skills. 1980.*
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Laboratory techniques for secondary school science education. 1984.

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* Out of stock

The Asia and Pacific Programme of Educational Innovation for Development (APEID) has as its primary goal the strengthening of the national capabilities for undertaking educational innovations related to the problems of national development, thereby improving the quality of life of the people in the Member States.

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Each country has set up a National Development Group (NDG) to identify and support educational innovations for development within the country and facilitate exchange between countries.

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3. Education and work;
4. Education and rural development;
5. Educational technology with stress on mass media and low-cost instructional materials;
6. Professional support services and training of educational personnel;
7. Co-operative studies and innovative projects of research and school-based experimentation related to educational development.

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